V1.0 – 10/01/2022

Apple powdery mildew

Apple powdery mildew infects young leaves, reducing vigour, yield and quality. Young fruitlets can be infected as well, and show weblike fruit skin russeting on mature fruits.

Research on damage thresholds shows that apple trees are relatively tolerant to mildew infections.

Growers should however be less tolerant as mildew epidemics can grow out of hand easily, and become difficult to control.

The RIMpro powdery mildew model implements all current knowledge on the infection biology and interaction with the host.

The model is 'host-central'. During each run a growing apple tree is simulated. The developing leafs can get infected while young, and contribute to the aerial spore population until they develop ontogenetic resistance.

The development of the mildew epidemic is mainly depending on air temperature and relative humidity. Therewith infection predictions are more stable than for diseases where infection risk depends on rain events.

Applications of fungicides with anti-sporulant or protectant activity should be aimed at days with a high infection risk.

The effect of primary inoculum and disease management on the simulation

Apple powdery mildew overwinters in buds. The fraction of mildew infected buds, as primary inoculum, is an important factor in the start-off of the epidemic.

By default the model simulates the disease development in an unsprayed apple orchard that keeps growing till late summer. In commercial orchards disease development is reduced by the application of fungicides and other control methods.

Primary mildew infections

Apple powdery mildew overwinters as mycelium in leaf- and flower buds. Infected buds open 2-5 days later than healthy buds. The growing mycelium covers the leaf tissue developing from these buds. These so called 'primary mildew infections' form the conidia source for secondary infections.

Sporulation and the effect of rain

Conidiophore development and spore development is simulated using a non-linear temperature-development relation, specific for apple powdery mildew. During darkness no mature spores are formed on the conidiophores.

The aerial spore concentration mostly follows a diurnal pattern with low levels during the night. The spore concentration in the air is positively correlated with temperature and VPD, and negative with RH, rain and leafwetness.

The spore production by the actively sporulating leaf surface is calculated using a modified version of the equation published by Xu in 1995.

Rain cleans the air from spores, and destroys the conidiophores, interrupting sporulation for some time until new conidiophores are formed.

Germination and viability of conidiospores

The number of spores landing on a leaf in each timestep is a function of the leaf surface, and the aerial spore concentration on that moment.

Under dry conditions the time un-germinated and germinating spores stay viable is depending on air temperature (Peries 1962). Under wet conditions spores are unable to germinate, and die within a few hours.

A relation between temperature and germination development was fitted to the data published by Molnar in 1971.

After germination, the further development of the infection is assumed to be independent from high RH conditions.

Susceptibility of developing leafs

Young leaves are only susceptible for mildew infections for 3-6 days. Most infections occur on the rolled leaves at the shoot tip. At the time leaves unroll they have developed about 0.1 of their final surface.

Leaves reach 15 % of their final leaf area approximately 175 DH after the initiation of the leaf at the shoot tip.

Incubation and growth of young mildew colonies

The latent time after infection is depending on temperature, apple cultivar, and leaf age. In the model only the effect of temperature is accounted for.

A relation between temperature and incubation development rate was fitted to the data published by Xu in 1996.

For the growth of young mildew colonies a relation between temperature and development rate was fitted to data published by Grove in 2002.

Effect of ontogenetic resistance on sporulation and colony growth

Mildew colonies grow and sporulate for about two weeks. Termination of colony growth, and of sporulation by the mildew colonies, is interpreted as an effect of increasing ontogenetic resistance with leaf age.

Using the default parameter setting ontogenetic resistance starts developing at leaf expansion 0.6, is 50% at 0.8, and the ontogenetic resistance is complete at 1.0: the moment the leaf reaches its final size.

Termination of tree growth

During summer the infection conditions for powdery mildew are optimal. Termination of shoot growth in July-August is the main factor limiting and stopping the disease progress.

In the current model version shoot growth terminates in August and stops further build-up of the disease.

Functionality for a more gradual and natural decrease of the number of growing shoots will be implemented later.